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Technologies for Augmented Collaboration

Social Domain Issues

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## Technologies for Augmented Collaboration Abstract

Teams have always been important in military operations, but the nature of military teamwork is changing to accommodate an increasing number of missions in stability, security, transition, and reconstruction (SSTR). These missions often require that diverse, distributed experts from multinational forces, non-governmental organizations, and other government agencies work together. Although team member diversity should improve mission performance by increasing access to a broader pool of knowledge, it is more likely to increase conflict and decrease trust, which may result in less information exchange, a lack of shared situation awareness, little team commitment, and ultimately poor team performance. Collaborative technologies generally focus on establishing physical interoperability among distributed team members, to the exclusion of technologies that promote cognitive interoperability. The Army Research Laboratory is investing in technologies to augment collaboration. The first tool is diagnostic, designed to assess cultural preferences and provide instruction on effective interaction strategies. The second tool uses Latent Semantic Analysis, a natural language and machine learning technology to monitor, moderate, evaluate, and provide feedback on team processes based on team communication. An initial capability of these tools was demonstrated in a Sudanese simulation; a revised system will be used in U.S. and Singaporean experiments.

## Technologies for Augmented Collaboration Outline

The Army conducts missions ranging from combat to peacekeeping and humanitarian assistance as a member of a diverse, often distributed, yet interdependent team. These missions are highly complex and dynamic and the teams needed to perform them are generally multi-service and increasingly have been multinational. Joint and multinational operations have been the norm in military command for the past 10 years. Evolving doctrine in response to lessons learned in Afghanistan and Iraq is expanding the military team and increasing the likelihood that the military will work with non-military agencies to plan and conduct operations currently being referred to as stability, security, transition, and reconstruction (SSTR) operations.

SSTR operations were recently established as a core U.S. military mission (United States Department of Defense, 2005). The objective of these missions is to help establish order with the aim of attaining a sustainable peace while advancing U.S. interests. U.S. policy on SSTR operations states that team membership shall be open to representatives from other U.S. departments and agencies, foreign governments and security forces, international organizations, U.S. and foreign non-governmental organizations (NGOs), and members of the private sector with relevant skills and expertise.

The key to successful performance in SSTR operations is the integration of civilian and military experts. In SSTR operations, each member of the team will be an expert in some aspect of the problem. Also, each team member will be advancing a particular agenda or, at least, likely to have a preferred approach to solving the problem. For example, is looting stopped by increased police patrols or more humanitarian relief? The military and NGO team member will probably vary in their approach to this problem. Team members may also differ in how they define the role of the military in performing critical SSTR functions like reestablishing basic services such as a sewage system, a functioning fresh water system, electricity, and trash removal.

The U.S. Army has prepared for and is comfortable with combat. However, the challenges currently facing the U.S. Army in Iraq and the missions it is likely to perform in the future require a different approach, one that is oriented toward achieving long-term regional stability. Consider the issues involved in determining the best method to defeat improvised explosive devices (IEDs). The U.S. military forces clearly have the training and the technology to find and kill at least some of the insurgents in Iraq before they can emplace IEDs, but to achieve long-term success requires the support of the local populace and that is best achieved by establishing or reestablishing security, basic services, and opportunities for growth (Chiarelli & Michaelis, 2005). Chiarelli and Michaelis (2005) state that “if there is nothing else done other than kill bad guys and train others to kill bad guys, the only thing accomplished is moving more people from the fence to the insurgent category—there remains no opportunity to grow the support base” (pg. 6). Current operations are more about winning the peace than winning the war. Thus, a combined approach, agreed upon through discussion and negotiation among experts in a variety of fields (U.S. and multinational military forces, other government agencies (OGAs),

NGOs, and local community and political leaders), will be required to address the complex, socially-oriented problems characteristic of SSTR operations.

These complex social problems are “wicked” problems in that there is no known solution and, in fact, merely defining the problem becomes a negotiation among experts (Buckingham Shum, 2003; Rittel & Webber, 1973). A wicked problem is characterized by an evolving set of interlocking issues and constraints and a problem solving process that is fundamentally social. There is no single “right answer,” and often it is more important to develop a solution that diverse stakeholders can accept and modify as the constraints on the solution change over time than to identify the best solution.

While team diversity is needed to perform the variety of tasks inherent in SSTR operations, if not supported the diversity of the team can actually interfere with collaboration to such an extent as to make the inclusion of additional expertise more a hindrance than a help in team performance (Panteli & Sockalingam, 2005). Therefore, researchers at the Army Research Laboratory Human Research and Engineering Directorate are leading a research program to develop technologies to augment collaboration among highly diverse, often distributed team members planning and executing SSTR operations.

### **Foundation Research in Bosnia-Herzegovina**

The research program began in 1999. The focus of the research at that time was to better understand how U.S. Army forces were being prepared for deployment to Bosnia-Herzegovina (B-H), and to use that knowledge to develop technologies to support military training and operations for peacekeeping missions (Pierce & Pomranky, 2001). Based on interview and observational data captured during the training phase of a unit deploying to B-H and post-deployment operations, several barriers to performance (Klein & Pierce, 2001; Pierce, 2002a; Pierce, 2002b) were identified. This work is reviewed here as the basis for the development of collaborative technologies to support the formation, preparation, and operations of military and civilian teams planning and conducting the highly uncertain missions characteristic of SSTR operations.

First among the barriers to performance was an assumption that an army prepared to fight could adapt its warfighting skills for peacekeeping. This assumption led to a “warfighting” mindset that influenced how training was conducted, the level of readiness the unit was able to achieve prior to deployment, and what tasks were given priority once the unit deployed. For example, rather than focusing on the unique skills needed in peacekeeping, pre-deployment training was designed to prepare the unit to respond to threatening situations that could occur in the area of operations, and once deployed the unit continued to plan for low probability, high threat events.

The mission of the sustainment force (SFOR) in B-H as defined by the General Framework Agreement for Peace (GFAP) was to insure a safe and secure environment. However, how best to achieve a safe and secure environment was subject to interpretation. The U.S. forces, leading Multinational Division North (MND(N)), tended

to maintain a high force protection posture and minimize risk by adhering to a narrow interpretation of the GFAP, whereas NGOs and other multinational forces supported a more liberal interpretation of the mission. A lack of agreement among team members on how best to achieve the mission led to a splintering of the command team with civil military operations tending to separate from the core Division staff which continued to plan for the worst case scenario. This separation was also seen between the staffs at Division and the Battalions, with the Battalions able to modify their approach based on their experiences in the communities they patrolled. The Division, however, operated from “behind the wire” at Eagle Base and were not able to gain the real world experiences needed to change their initial understanding of the area of operations and operational mindset which was incorrectly established during pre-deployment training.

In addition to the warfighting mindset, training was done without meaningful representation from other groups that the unit would be working with at MND(N). These groups included a Civil Affairs Battalion from the National Guard, multi-national forces, NGOs, and local political and military leaders. In interviews with the research team at 1, 4, 6, and 10 months post-deployment, many of the unit members reported that their training had not given them an accurate picture of their steady-state peacekeeping mission, nor did it prepare them to work as a member of a diverse team. A lack of interpersonal skills necessary to work with local community and political leaders and aid agencies was reported as the most significant training shortfall.

MND(N) was led by the U.S. forces and although there were multinational forces in MND(N) from Russia, Turkey, and a NordPol group that included a combination of Nordic and Polish forces, interaction between the U.S. and these multinational units was minimal. During the time that the ARL research team was interviewing unit members and observing operations, the only non-U.S. staff member, was the G-5, Civil Affairs, chief. He was supported by a U.S. deputy and due to rules excluding foreigners from key intelligence briefings, the deputy became the primary interface with the Division staff, further marginalizing the impact of non-U.S. team members on MND(N).

To better understand the impact of cultural diversity on military command and control, the research effort was expanded to SFOR headquarters. At SFOR headquarters, the U.S. led a multinational command group of more than 30 nations. The research team’s focus at SFOR headquarters was to better understand the cultural barriers to teamwork in a multinational military setting and to identify methods to overcome these challenges (Bowman & Pierce, 2002). Using a combination of structured interviews, focus groups, and observations, the research team found culture to affect communication and coordination within and across command cells.

Based on the research conducted at MND(N) and SFOR headquarters, the research team concluded that a warfighting mindset and a lack of skill in working with organizationally and nationally diverse team members caused peacekeeping expertise to develop slowly, if at all. Decision-making tended to be reactive and risk averse. Teams were not adaptable and there was a planning focus on efficiency which emphasized product completion over inclusiveness. The bottomline was that core U.S. forces did not exploit the expertise of

multinational partners or civil-military staff members. To address these challenges a research program was initiated to develop technologies to prepare and support culturally adaptable teams, with cultural adaptability being comprised of teamwork, adaptability, and culture (Sutton, Pierce, Burke, & Salas, 2006).

### **Teamwork**

Team performance results from individual competence plus team competence, individual and team accountability, and team reward. Team competence is determined by the ability of the team to assign roles and responsibilities, exchange information, coordinate actions, error check or provide supporting behavior, and act as a source of motivation (Fleishman & Zaccaro, 1992; McGlynn, Sutton, Sprague, Demski, & Pierce, 1999). Using a purely additive approach to determine the potential for team productivity, researchers have found that teams often perform worse than would be expected by the ability of the individual team members. Steiner (1966, 1972) called the discrepancy between potential productivity and actual team performance “process loss.” Process loss can be due to either poor coordination or a lack of motivation. Coordination losses occur when group members do not optimally organize or combine their responses. Motivation losses result when team members work less hard in a group than they would if they were alone.

Steiner’s model assumes that team performance cannot exceed the sum of individual performances. In actuality, team performance often surpasses Steiner’s potential productivity equation (Beck & Pierce, 1996). Teams may do better than expected for a variety of reasons. Team members may catch one another’s mistakes or assist teammates with excessive workloads. Team membership may also heighten, rather than reduce motivation. Teams are needed to share their expertise and the workload, and monitor and help one another (Smith-Jentsch, Mathieu, & Kaiger, 2005). However, for process gain to occur requires that the team engage in team process behaviors that promote team competencies such as information exchange, coordination, error checking and motivation among team members. As an example, Cannon-Bowers, Salas, and Converse (1993) have demonstrated that coordination among team members is facilitated by a clear understanding or team mental model of the knowledge shared by team members. Collaborative technology that not only supports information exchange, but also aids in the development of a good team mental model should improve team performance.

### **Adaptability**

Burke, Stagl, Salas, Pierce, and Kendall (in press) have defined team processes for adaptable team performance. They define team adaptation as “a change in team performance, in response to a salient cue or cue stream, which leads to a functional outcome for the entire team” (Burke et al., in press). Generally speaking, carrying out a new plan requires communication and coordination of actions, while monitoring and back-up behavior assist team members when cognitive or physical resources become depleted (e.g., in high stress situations). The complexity, uncertainty, and dynamic nature of SSTR operations makes adaptability an essential element of team performance (Burke et al., (in press); Burke, Salas, Estep, & Pierce (in press)).

As described by Burke, Stagl, Salas, Pierce, and Kendall (in press) the adaptive cycle includes situation assessment, plan formulation, plan execution, via adaptive interaction processes, and team learning. In addition to these process variables, team adaptation is affected by emergent cognitive states such as shared mental models, team situation awareness, and psychological safety. Process variables describe team member interaction, while emergent states describe the cognitive, motivational, and affective state of the team (Marks, Mathieu, & Zaccaro, 2001). It is proposed that measures of emergent states such as shared mental models, team situation awareness, and psychological safety, can provide the predictive link between team processes (establishing roles and responsibilities, information exchange, coordination, error checking, and motivation) and mission performance (timeliness, accuracy, etc.).

A team has a shared mental model to the extent that they have a common understanding of how the team operates (Smith-Jentsch, Mathieu, & Kraiger, 2005). Team situation awareness (TSA) is a shared awareness of the current situation at a given point in time (Salas, Prince, Baker, & Shrestha, 1995). TSA is comprised of perception of environmental elements in relation to time and space, understanding of which of these elements are noteworthy in relation to the team's goals, and the ability to forecast future events in light of the current situation" (Endsley, 1995). In team operations, shared mental models and team situation awareness can be measured using a variety of techniques to assess operational awareness of the team and the situation at pre-determined intervals.

The third emergent state that is especially important in multicultural teamwork is psychological safety. Edmondson (1999) defined team psychological safety as the shared belief that the team is safe for interpersonal risk taking. Psychological safety is characterized by a team climate of interpersonal trust, mutual respect, and a feeling of comfort with interpersonal risk taking (Edmondson, 1999; Schein & Bennis, 1965). Psychological safety does not play a direct role in team performance, but rather facilitates team members taking appropriate actions to accomplish work. Teams are needed in part because members have different vantage points, as well as different levels or types of expertise and knowledge that can be called upon to address problems as they arise. This is especially important in cognitively complex, uncertain environments. Teams will only be effective to the extent that their diversity is tapped in problem solving.

Trust, an aspect of psychological safety, enables conflict, and conflict if used constructively, can help teams to explore differences, promote greater knowledge sharing and more importantly stimulate knowledge creation which stems from learning and leads to innovation (Panteli & Sockalingam, 2005). Trust changes over time through phases depending on the need for trust, the type of conflict experienced by the team, and how conflict is managed. Panteli and Sockalingam (2005) describe three types of trust and three types of conflict. Types of trust are calculus-based, knowledge-based, and identification-based trust. Types of conflict include relationship or affective, task or cognitive, and process. A high level of trust can be achieved by resolving or managing conflict due to relationships and processes and by promoting the safe expression of task



or cognitive conflict. For command teams to be adaptable in planning and conducting full spectrum missions they will at least need to achieve knowledge-based trust, but performance will be improved if the team is able to achieve identification-based trust.

## **Culture**

The final component of cultural adaptability is culture. Culture is the framework within which experiences are interpreted and values are formed. Culture influences behavior, to include team behavior (Sutton & Gundling, 2005; Sutton & Pierce, 2003; Sutton, Pierce, Burke, & Salas, 2006). Among other things, cultural norms can determine who can and can not speak to whom, what information can be shared up and down the chain of command or among ones' peers, how much information is needed to make a decision, and who does what task. Klein, Pongonis, and Klein (2000) propose that interactions among members of multinational teams will improve if team members see the world through each other's eyes (i.e., through a "cultural lens"). Sutton, Pierce, Burke, and Salas (2006) call this cultural competence, stating that culturally competent teams understand the dominant values and orientations of other team members and recognize that the thoughts and behaviors of others may be influenced by culture.

## **Cultural Adaptability**

Technologies that promote cultural adaptability (teamwork, adaptability, and cultural competence) among nationally and organizationally diverse team members solving complex (ill-structured, ill-defined) problems in uncertain and dynamic environments are needed. We propose that cultural adaptability can be achieved by technologies that facilitate the development of shared mental models and team situation awareness. In addition, these technologies should increase psychological safety as measured by decreased relationship and process conflict, increased trust, and increases in the healthy forms of task or cognitive conflict which have been found to result in more creative, innovative solutions and adaptable teamwork. The GlobeSmart® Commander and Latent Semantic Analysis are two technologies being developed to promote cultural adaptability in SSTR operations.

### *GlobeSmart® Commander*

GlobeSmart® Commander is an instructional tool designed to provide military teams performing command and control functions the information and skill they need to adapt to cultural influences on teamwork at the operational level (Sutton, 2003; Sutton & Cosenzo, 2004; Sutton & Edelman, 2005; Sutton & Pierce, 2003; Sutton, Pierce, Burke, & Salas, in press). Six cultural dimensions are assessed by GlobeSmart® Commander (Sutton & Gundling, 2005). These dimensions reflect basic culturally-based values or orientations identified in the culture literature (e.g., Hofstede, 1980; Schwartz, 1992; Triandis, 1989; Trompenaars & Hampden-Turner, 1998). Following is a list of the dimensions included in GlobeSmart® Commander along with a short description of each dimension.

Dimension	Practical Implications
Independent – Interdependent	Shapes a preference for individual initiative and action, or for a more group-oriented approach that emphasizes the interests of the team as a whole.
Egalitarian – Status	Shapes a preference for mutual consultation in decision-making, or for greater deference to rank and hierarchy.
Risk – Restraint	Shapes a preference for rapid action and risk-taking, or for more cautious and calculated actions based on ample information.
Direct – Indirect	Shapes a preference for open and explicit communication, or for careful attention paid to context or to implicit meanings in a given message.
Task – Relationship	Shapes a preference for immediate attention to getting the job done, or for establishing strong and trusting personal relationships first.
Short Term – Long Term	Shapes a preference for making choices based upon a narrow time horizon, or for considering the impact that choices will have over a longer span of time.

While each of these dimensions was considered important in multinational team operations to operational level staff members in B-H, reported critical incidents tended to focus on the dimensions of independent-interdependent, egalitarian-status, and risk-restraint. These three dimensions, slightly redefined, seemed to be especially important in team performance (for a detailed review see Sutton & Pierce, 2003; Sutton, Pierce, Burke, & Salas, 2006).

The GlobeSmart® Commander tool includes an introductory lesson and ten learning modules. The first lesson is an introduction to the importance of culture and a description of its impact on teamwork. This lesson includes examples taken from the field in B-H and at subsequent multinational exercises. The intent of the introduction is to raise awareness of the impact of culture on individual and team performance. Following the introduction is a 32-item survey pertaining to one's preferred work style. The survey and the survey algorithm were developed by MeridianEaton Global with the assistance of Dr. David Matsumoto at San Francisco State University (Sutton & Gundling, 2005). Based

on the survey, an individual's profile representing each of the six dimensions described above is created. Throughout the instructional session, the user can compare his or her profile to that of national averages for many nations represented in the National Atlantic Treaty Organization and Partnership for Peace in addition to selected Asian nations. The first six modules introduce the topic of cultural differences and provide an orientation to each of the six dimensions of culture designed to build awareness of how culture impacts teamwork.

Each instructional module begins with a video scene in which cultural differences are having a negative impact on team performance. At the conclusion of the video, a narrator explains the key differences between the two sides of the dimension represented in the situation. This is followed by a presentation by the two actors representing the opposite extremes of the dimension and a discussion by the narrator on the importance of people with differing styles being able to work together. This allows the user to see the situation from both perspectives. The final component of the dimension modules is a series of interactive exercises to insure the user understands and can apply the lessons learned about cultural differences.

The final four modules of the GlobeSmart® Commander cover several aspects of multicultural teamwork that correspond with the "Forming," "Storming," and "Norming" phases of team activity. These modules use the same general approach as the dimension modules, beginning with a video scene, followed by the actors presenting their perspectives and challenges in team formation. The discussion references learning from the previous dimension modules, with several key points pertaining to the importance of developing relationships and the impact that the perceived lack of trust based on cultural differences has on overall team performance. After the perspectives and challenges sections, the instruction moves to techniques that can be employed to improve the functions of the team. Each technique is demonstrated so the user can see the difference it has on the situation. For example, the techniques in the team start-up module include: create a structured meeting process; implement turn-taking to provide the opportunity for each person to contribute; find ways to build relationships; facilitate communication so non-native English speakers understand what is being said; and build trust through careful hand-offs and systematic instruction. After watching each technique separately, the entire scene is played out using the new techniques so the user can clearly see how the situation is improved from the first scene.

Significant cultural differences have been found to interfere with mission success when cultural knowledge is lacking (McFarland, 2005). The inability to adapt, as necessary, to the influences of culture on thoughts and behavior can result in imperfect situational awareness, which can lead to inaccurate situations assessment, and flawed or delayed decision making. We propose that cultural adaptability is critical to mission success in multicultural military environments, particularly at the operations level. Cultural adaptability includes the ability to recognize the influences of culture on teamwork, understand how best to act and react to those influences, and, most importantly, take action by choosing to adapt.

### *Latent Semantic Analysis*

The communication among team members is one of the richest sources of data about the team's performance and process. However, the use of communication data to predict team performance has been limited due to the labor intensive and time consuming processes involved in both capturing and analyzing the data. Natural language and machine-learning technologies have strong potential to be used for analyzing spoken and written communication among team members. Technologies for analyzing the semantics and syntactical properties of language can be combined to provide tools that can characterize the quality and content of information being conveyed in these communication streams (Foltz, 2005). Using the verbal content of spoken and written communication, such a toolset can be used to improve ad hoc team formation and functioning and has the potential for providing near-real-time assessment (within seconds) of individual and team performance including measures of situation awareness, knowledge gaps, workload, as well as predictions of future performance based on analyses of the current context.

Latent Semantic Analysis (LSA) is a machine learning algorithm that understands the meaning of words and text in much the same way as humans (Landauer, Foltz, & Laham, 1998). LSA uses a fully automatic mathematical technique to extract and infer meaning relations from the contextual usage of words in large collections of natural discourse. LSA has been applied to a wide range of domains, including cross-language information retrieval systems, automatic essay scoring systems, as well as in systems for monitoring and providing feedback based on spoken and written team communications.

Initial tests of LSA-based team communications analysis methods have shown great promise. Using existing command and control communication data sets, the technology is able to provide accurate predictions of the overall team performance, make reliable judgments of the type of patterns of communication among team members (Foltz, 2005; Foltz & Martin, 2004; Gorman, Foltz, Cooke, Kiekel, & Martin, 2003; Kiekel, Cooke, Foltz, Gorman, & Martin, 2002).

LSA technology has been incorporated into online collaborative environments that can monitor, moderate, evaluate contributions, and provide feedback to users and access to hundreds of digital material (e.g., books, doctrine, and manuals). Tests of the technology on U.S. military officers and cadets show that they make measurably higher quality contributions using the technology than when discussing the same issues face-to-face. When the system automatically interjects expert comments into the discussion by the automated moderator, cadet contributions are of significantly higher quality than in instructor led classes or electronic discussion groups without the feature (LaVoie, Streeter, Lochbaum, Wroblewski, Boyce, Krupnick, & Psotka, submitted).

In the present application, LSA-based tools monitor written communication streams from teams. The tools support ongoing collaboration by identifying the quality of the team performance and analyzing such performance measures as convergence of contributions, coherence among team members, degree of topic-related discussion, and identification of

critical incidents. The output of the performance measures are then used with visualization tools to provide officers with overviews of the performance of teams in order to enhance overall situation awareness. The output from such a toolset can further be used for tracking teams' behavior and cognitive states, identifying critical incidents, determining when appropriate feedback needs to be given, for generating automated after action reviews, and adapting interfaces to provide relevant data to teams.

The LSA-technology is being developed using a client-server model, with an internet-based server for performing analyses and the ability to receive communication data from clients (e.g., Information Workspace, MissionMate, etc.) and return team and individual performance measures to the clients. As such, the technology has a broad scope of application and can be used for ad hoc team formation, collaboration support, mission planning and information gathering. By providing teams and their commanders with self-monitoring tools, the technology can improve the quality and speed with which teams form and perform.

### **Technologies for Augmented Collaboration**

Technologies for augmented collaboration (TAC) will improve team formation by helping to identify who and what expertise is needed by the team, assessing their availability, and providing instruction on how to facilitate interaction among team members. A team coach module will support team member interactions by providing information on how and what type of information is being shared by the team, identifying gaps in knowledge, and keeping a running summary of the discussions and the discussion themes. A team meter will monitor the extent to which the team is on task and identify new information sources. The final tool will allow the team to visualize interactions and performance and understand when adaptation is needed and how to adapt. A prototype TAC was used in one simulation and will be used in an upcoming battle command exercise between the U.S. and Singapore. Lessons learned from both events will be used to refine the TAC for use in future collaboration information environments.

#### *Darfur Sudan Simulation*

An initial TAC capability was demonstrated in a simulation requiring collaboration among diverse, distributed experts. For this demonstration TAC included an LSA-enhanced discussion forum called Knowledge Post (KP) and a technology for dynamic network analysis (DNA). Dynamic Network Analysis (for a review see Carley, 2003) provided an on-going overview of who was connected to whom, what knowledge individual participants had, and what tasks they were responsible for completing. GlobeSmart® Commander was not used in this demonstration.

The scenario, a classic wicked problem, was set in Sudan's Darfur region. As context, a fictionalized mission in which a Joint Task Force commander was deployed to the South Darfur state to assume command of all U.S. forces comprising the Multinational Force (MNF) was created. The civil-military-based scenario was driven by events related to internally displaced persons and security. Team members included the civil-military

operations director, the local civil affairs lead, an NGO regional director, a United Nations representative, a refugee camp director, a representative from an oil company working in the region, and a representative from the local community. Five subject matter experts participated in the simulation, assuming these seven fictional roles.

The main goals for running the simulation were to: determine the feasibility of building productive multicultural collaborative teams in an asynchronous online environment; test the ability of TAC to support complex collaborative efforts; identify and test a set of metrics for evaluating the collaboration process; and identify the extent to which the discussion interface met the user requirements for a collaborative tool.

All communications among team members were asynchronous, using KP, a web-based, threaded online discussion interface enhanced with LSA and DNA features designed to support collaboration. For example, the KP responded to group needs by providing data from the library that supported the need for protection of NGOs as requested by the camp director for the United States Agency for International Development (USAID). DNA maps provided an easily interpretable visualization of a prospective group member's social network, including the individual's relationship of connections (who knows whom?) and influence (who has power over whom?).

Participants were provided with a one-hour introduction to the scenario topic, the roles they would play, and the technologies they would use. Participants were encouraged to introduce additional issues as the scenario progressed in order to make the simulation as spontaneous and lifelike as possible. For the demonstration, the participants spent two weeks using TAC to build a collaborative team and to work through the problems presented. Data were collected on each character's participation (comments submitted as well as comments read), the relevance of comments to the topics at hand, and the degree of consensus reached by the group.

Without formal introductions or face-to-face encounters, team members had to rely on the collaborative tools provided to facilitate the team building process. These interrelated processes, which occurred in conjunction with the problem solving activities, included building trust, managing cultural differences, and leveraging areas of common interest. TAC facilitated collaboration in this demonstration by helping the team to quickly understand who was on the team, what their cultural affiliations were, what their perspectives were on issues, and the extent to which there was agreement among the members.

TAC also helped participants to manage the influx of comments and references and the overall flow of the collaboration itself. KP provided summaries of the discussion content, automatically inserted germane texts into the discussion, and identified closely related information, thereby discouraging redundant actions. KP also supported coordination of efforts, identifying implicit tasks and proposing viable solutions (e.g., security needs for food distribution efforts).

TAC was designed to capture team process measures. Some of the measures collected each day were number of comments posted, average length of the comments, number of comments read, number of library interjections read (material identified by KP as important to the discussion), consensus scores, and number of ego nets reviewed. In addition, TAC provided feedback to the team on the semantic relatedness between and among the discussion threads, and on who was replying to whom. TAC also created a set of keywords to summarize the content in the most commonly read notes. Although not done in this exercise, TAC could also have computed the percentage of the discussions that were on or off the topic and the coherence among notes.

Overall, the reaction of participants to the simulation and the technology used was positive. In post-study interviews participants identified the following capabilities as integral to the collaborative problem solving process: getting live updates from the field (i.e., the setting of the problem to be solved); getting background information on potential collaboration teammates, including areas of expertise, social networks, and cultural background; assistance in establishing and building rapport with teammates; and efficient methods of exploring and navigating discussion threads.

### *US and Singapore Command Exercise*

A U.S. and Singapore Command Exercise will be conducted in September 2006 to evaluate the utility of TAC tools GlobeSmart® Commander and LSA, for use in preparing and supporting a multicultural command team. Singapore will develop a realistic, simulation-based scenario, which will include operations other than war such as disaster relief with a counter terrorism or homeland security component.

The independent variables will include type of planning system used and the presence or absence of the TAC tools. The dependent variables will include team processes, emergent states, and outcome measures. The process and emergent state measures will be captured by LSA and using survey instruments administered at pre-determined times during the exercise and at the end of the exercise. The survey instruments will be used to assess shared mental models, team situation awareness, and psychological safety as measured by the degree to which team members trust one another and their commitment to the team and team products. Outcome measures will be mission-based and captured by the simulation and through observation. Results of the simulation will be used to refine the TAC tools.

### **Summary**

In this paper, we achieved three main objectives. First we defined a new type of military command and control challenge, one that requires dynamic, social-negotiation and collaboration among highly disparate multicultural team members. Second, we described a conceptual model of cultural adaptability based on the research literature in teamwork, adaptability, and culture. Finally, we proposed two technologies, GlobeSmart® Commander and LSA and discussed how each could be used to improve and evaluate multicultural team performance.

These technologies can be leveraged to provide recommendations for system requirements that address unmet or, as yet, unidentified needs of multicultural teams at the Joint Task Force level. They can be used to mitigate threats to information sharing and improve decision making performance on interagency task forces. In addition, the embedded survey tool can be used to identify cultural profiles for the purpose of populating cultural variables in a multitude of exiting team performance models or in representing multicultural human behavior in models and simulations.

Of course, the significance of this work is in its relevance to current operations. The U.S. Army maintains its proficiency in “kinetic” warfare, but continues to struggle to define processes and technologies for irregular warfare (Aylwin-Foster, 2005). In SSTR operations, civil-military cooperation is essential. The model of cultural adaptability described above and the technologies proposed to augment multicultural teamwork are representative of the class of models and tools that will be needed in the global war on terrorism, campaigns that may be more about winning the hearts and minds of the local population than traditional, attrition warfare.

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# ***Army Research Laboratory***

Human Research and Engineering Directorate

## ***Technologies for Augmented Collaboration***

**Pierce, Sutton, Foltz, Lavoie,  
Scott-Nash, and Lauper**

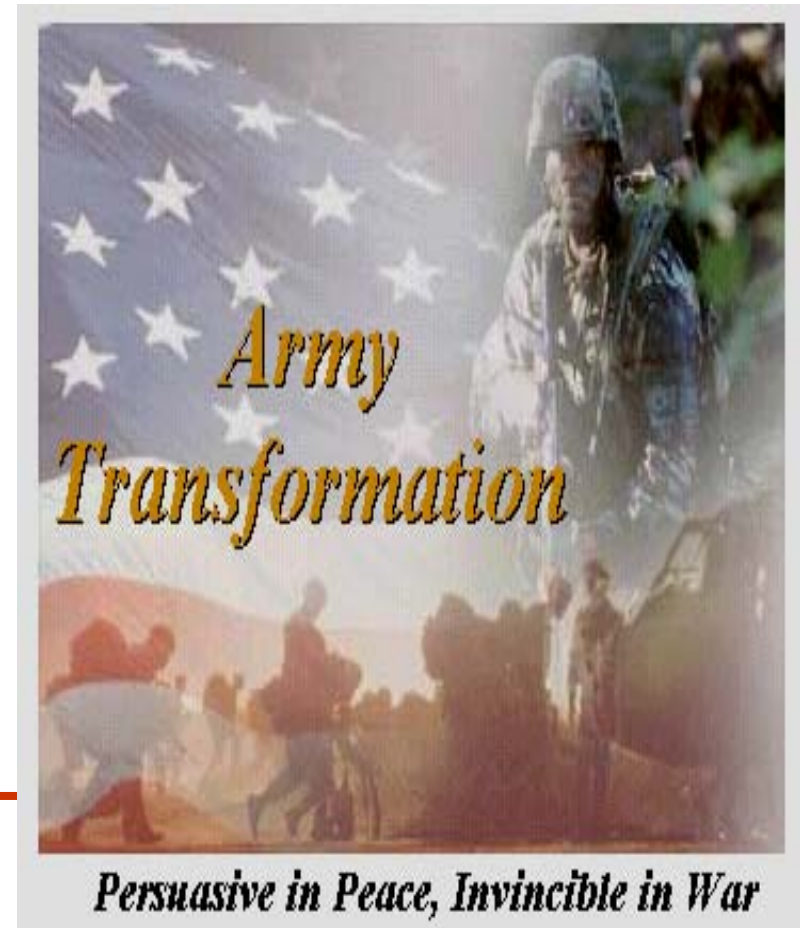
**2006 CCRTS**

**The State of the Art and the  
State of the Practice**

**Presented by:**

**Dr. Linda Pierce, Chief,  
Soldier Performance Division,**

**ARL HRED [lpierce@arl.army.mil](mailto:lpierce@arl.army.mil) 410.278.5846 (DSN 298)**



# ***Future Force for Full Spectrum of Missions***

## **Environmental Complexity**

**High**  
**Urban**



**Open**  
**rolling**  
**terrain**



**Low**

**Major Theater**  
**War**

**Small Scale**  
**Contingencies**

**Security, Transition,**  
**and Reconstruction**  
**Operations (STRO)**

**Spectrum**  
**of Conflict**

- **Future Battlefields**
  - More rapid tempos
  - Diverse missions
  - Culturally diverse teams
  - Distributed teams
- **Future Force**
  - Rapid deployment
  - Rapidly forming/reforming teams
  - Dynamic team building with diverse team members
  - More decentralized decision making
  - Novel problem solving for situations not covered by standard doctrine
  - Execution based planning

***Renders Previous Ways of Warfighting Obsolete***

# ***Stability, Security, Transition and Reconstruction Missions are “Wicked” Problems***

- **Simple Scenario:**
  - Unit conducts a deliberate assault on regime forces defending a capital city (*decisive battle*)
  - Battle staff plans and executes the operation using practiced battle staff drills
- **Complex Scenario:**
  - Unit conducts an assault on insurgency forces in an ethnically sensitive area (*asymmetric engagement*)
  - Battle staff must extend battle calculus and adapt doctrine to address non-traditional adversary
- **Wicked Scenario:**
  - Unit coordinates peacekeeping operation with coalition partner who disagrees with priority of objectives (*protect ethnic population vs economic reconstruction*) and methods of engagement (*“iron fist” vs “velvet glove”*)
  - Battle staff must collaborate extensively to define objectives, constraints, and range of appropriate actions



***Negotiation among culturally diverse team members is an essential feature of wicked scenarios!***



# ***Understanding Requirements***

- Data were collected during Task Force Eagle (TFE) pre-deployment training (FY00).



- Structured observations and interviews were conducted at TFE Division and Battalion command posts at 1, 4, 6, and 10 months post deployment (FY01).



- Research was expanded to include multinational teamwork at SFOR HQ - data were collected quarterly (FY02-03).
- Research was supported by an MOA between ARL and FORSCOM.

# *Observations from Bosnia-Herzegovina*

- **Training**
  - Training in peacekeeping was not routine.
  - Training environment was complex and afforded limited feedback or replay.
  - Steady state skills were not well trained.
    - Information operations
    - Influence, persuasion and negotiations
  - Civil affairs or Civil Military Coordination (CIMIC) was not well represented.
  - Interaction with international agencies and multinational forces was limited.
- **Organization**
  - Warfighting mindset
  - Personnel instability
  - Procedures discouraged multinational cooperation
- **Technology**
  - Little collaborative technology for peacekeeping for:
    - Pattern analysis
    - Situation assessment
    - Historical and biographical databases
  - Technology supported centralized control.



# ***Bottomline***

## ***Impact on Performance***

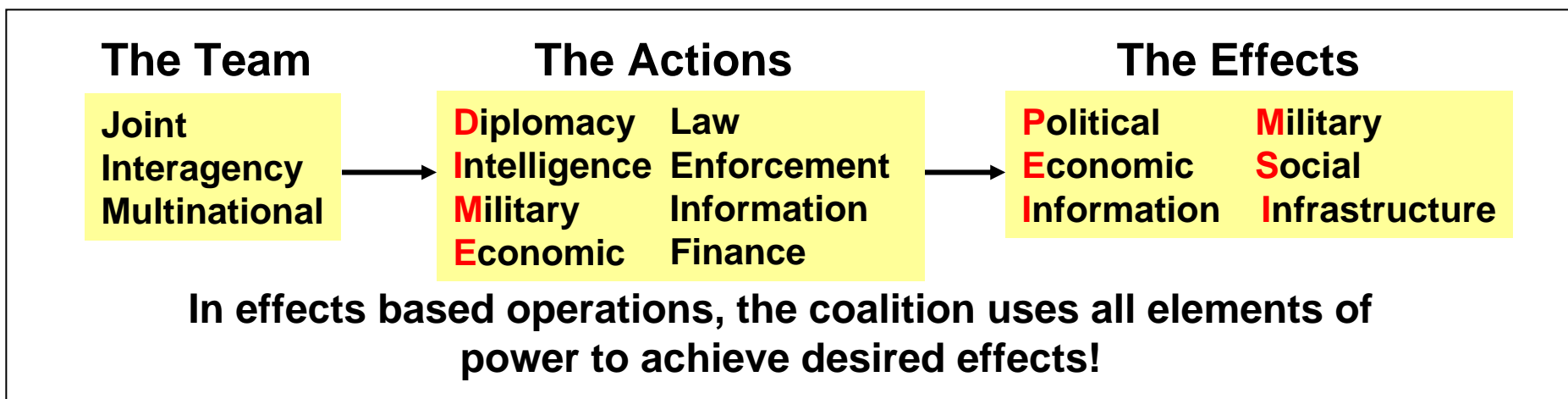
- **Peacekeeping expertise was slow to develop.**
- **Decision-making tended to be reactive and risk averse.**
- **Teams were not adaptable.**
  - Focus on efficiency
  - Limited information exchange
- **Teamwork was inefficient.**
  - Team diversity was not exploited
  - Civil affairs or CIMIC was not integrated into core staff planning or operations





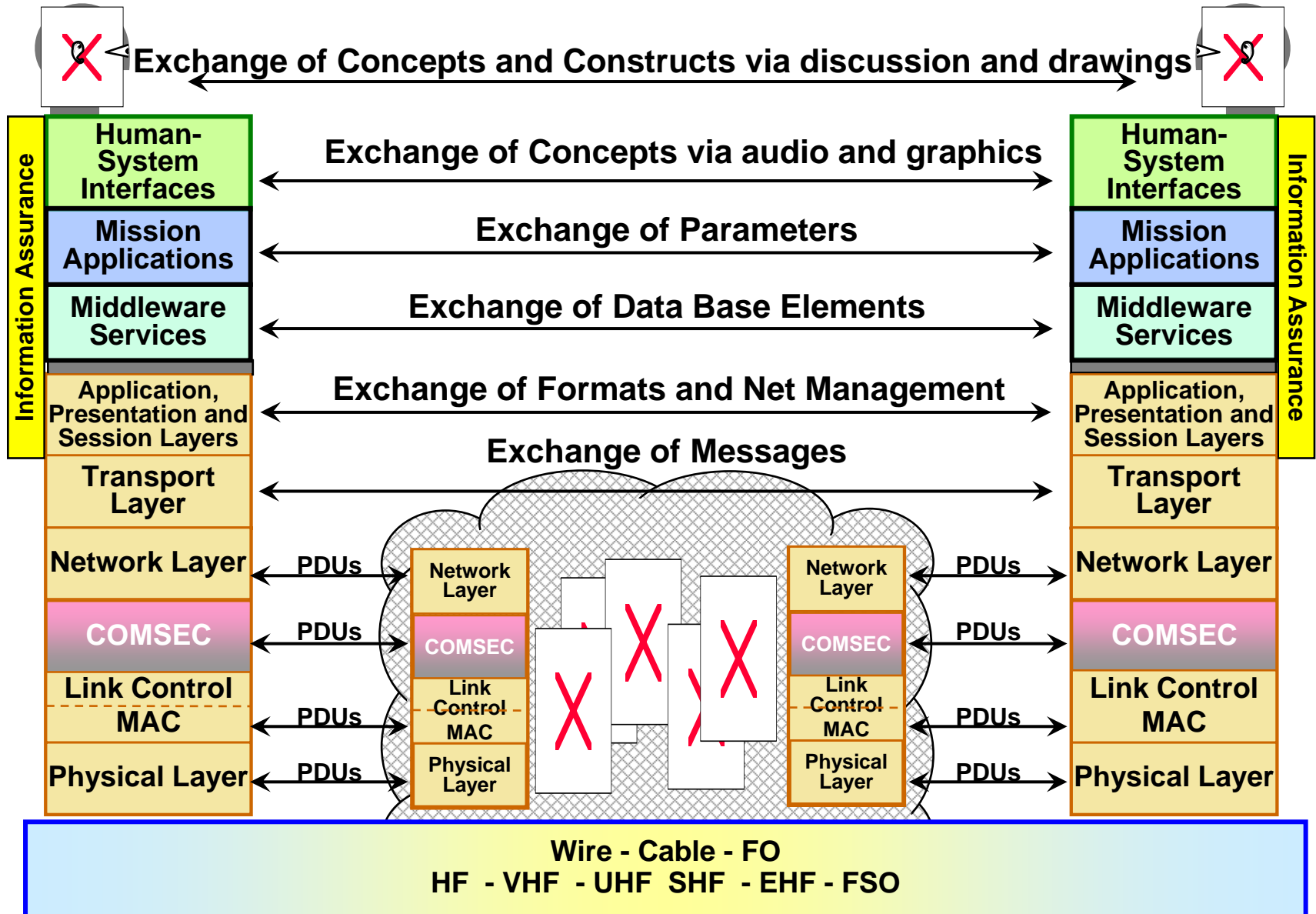
# *Effects Based Operations*

- The Army must undertake a major effort to transform the way it operates. The transition is to an **effects-based approach to operations**.

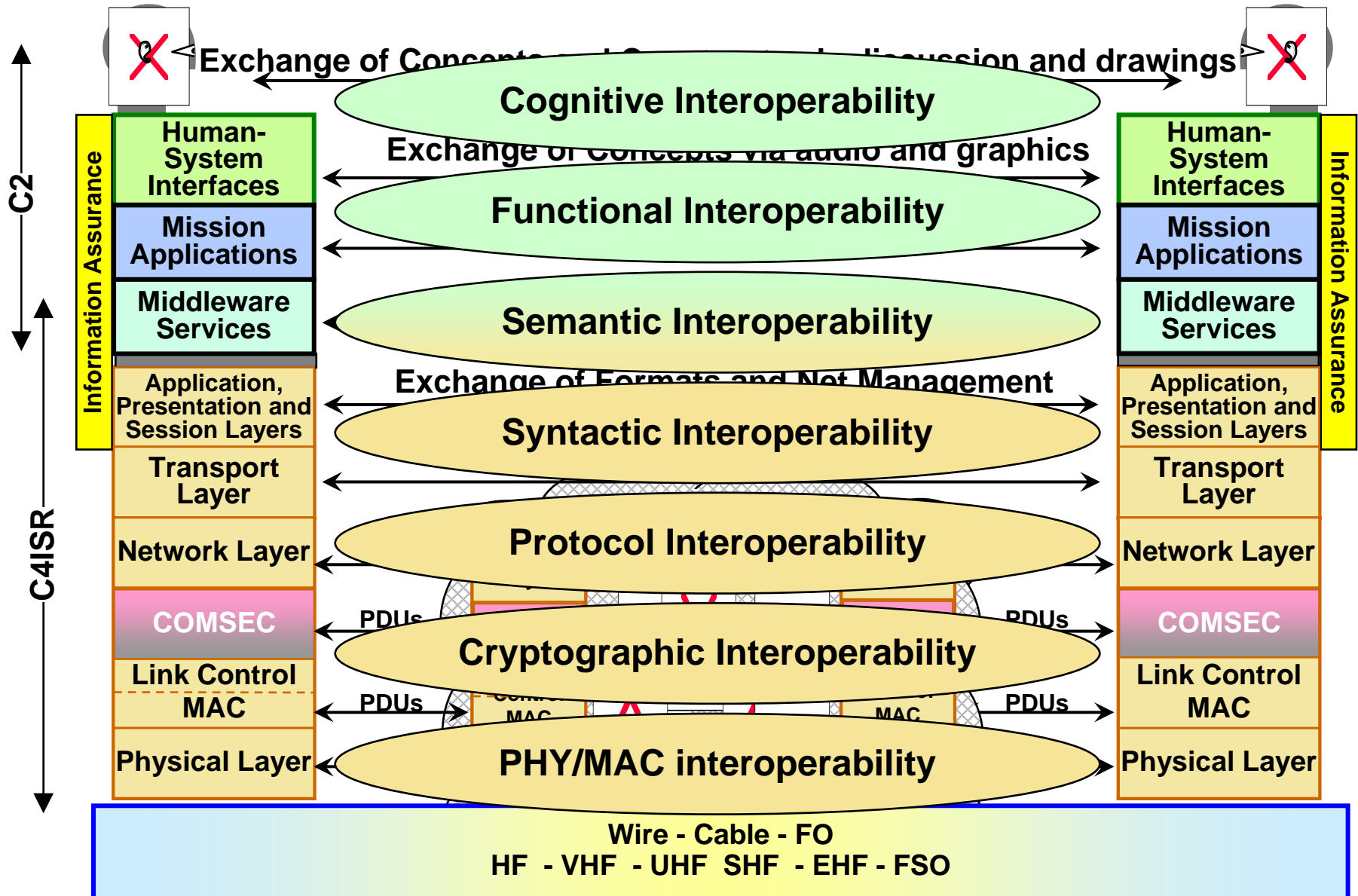


- All **recent operations have been coalition operations**.
- Effects based operations require **collaboration** among diverse, often distributed coalition partners.
- This program will develop software technology that significantly increases the ability of the U.S. Army to effectively **form coalitions, lead multicultural teams and execute** effects-based operations.

# Information Exchange



# Interoperability Areas



# ***Effects Based Operations Require Multicultural Collaboration***

## **A Possible Team**



U.S. and Multinational Forces, Other Government Agencies,  
Non-Government Organizations

***The ability to  
interoperate is  
necessary but not  
sufficient to insure  
effective collaboration.***

## **Potential Barriers**

- **Limited understanding of team member roles and responsibilities**
- **Little information exchange**
- **Poor team coordination**
- **Little giving or receiving of assistance**
- **Little motivation to work with others on the team**

## **Implications**

- **Inaccurate team mental model**
- **Inaccurate team situation awareness**
- **Limited trust**
- **Increased conflict**
- **Social loafing or groupthink**
- **Risky decision making**
- **Lack of commitment to the team**
- **Little innovation or risk taking**
- **Poor team performance**

# ***Descriptive Model of Multicultural Collaboration***

## **Input**

### **Team Member Culture**

- Independent-Interdependent
- Egalitarianism-Status
- Risk-Restraint
- Direct-Indirect
- Task-Relationship
- Short term-Long term Orientation



## **Processes**

### **Team Functions**

- Roles and Responsibilities
- Coordination
- Information Exchange
  - Amount/Type/Quality of information
  - New Ideas
- Giving and receiving aid
- Motivation



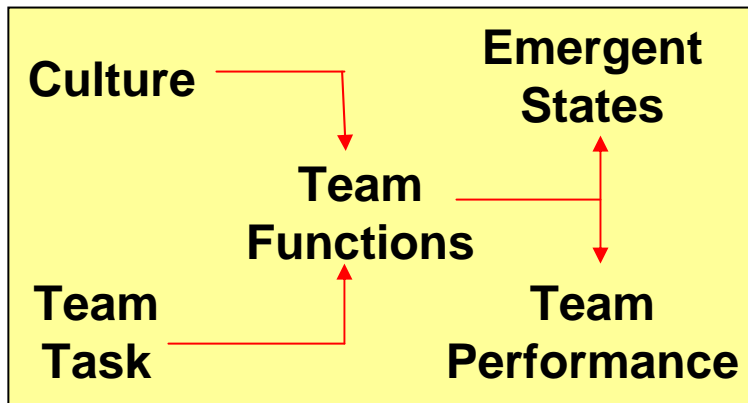
## **Measures**

### **Emergent States**

- Team Mental Model
- Individual and Team Situational Awareness
- Psychological Safety
- Trust

### **Outcome Measures**

- Scenario Success
  - Accuracy/Quality
  - Timeliness
- Workload
- Progress Towards Goals
- Commitment to the team and team decisions
- Consensus - Convergence/Divergence of Ideas
- Range of Issues Considered



# ***Technologies for Augmenting Multicultural Collaboration***

- **GlobeSmart ® Commander** – Tool to assess cultural biases in cognition and teamwork and improve interaction among diverse team members.
- **Latent Semantic Analysis** – Automated techniques for text understanding that compare and determine the degree of semantic relatedness between any two texts.
- **Dynamic Network Analysis** – Computational models of the relationship among people, resources, tasks, and knowledge generated through real time monitoring of interactions.

# Improving Multicultural Collaboration in Effects Based Operations

## Technologies for Augmented Collaboration

### The Environment

#### The Team

Joint  
Multi-agency  
Multi-national  
Non-government

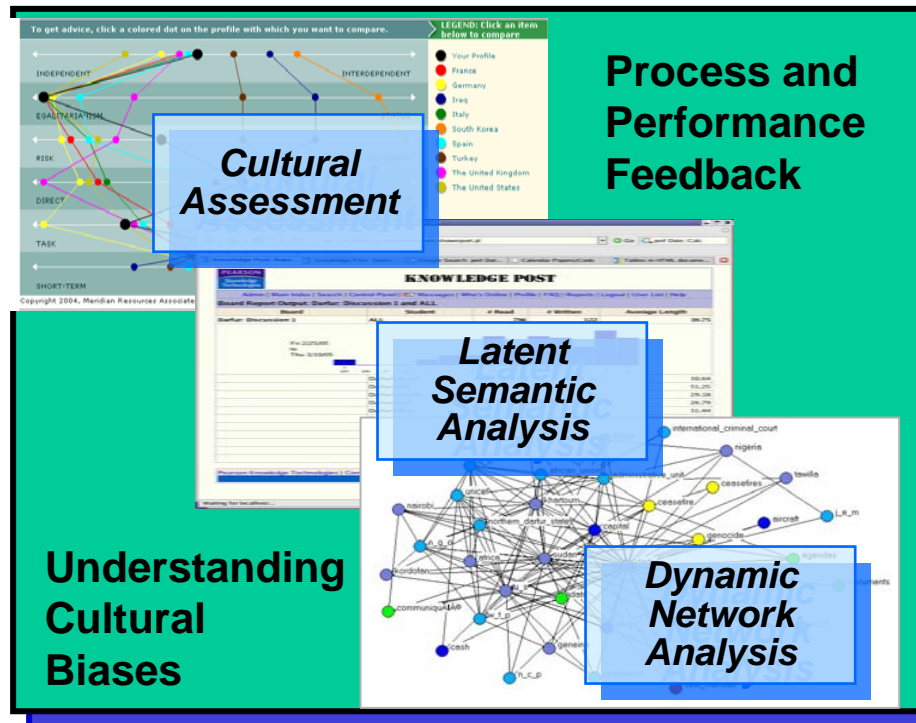
#### The Actions

Diplomacy	Law
Intelligence	Enforcement
Military	Information
Economic	Finance

#### The Effects

Political	Military
Economic	Social
Information	Infrastructure
	Other

### Collaboration



### Support Functions

**Team Formation**  
Who should be on this team?



**Team Coach**  
What does the team need?



**Understanding**  
What is the team doing?



**Team Meter**  
Is the team generating viable solutions?

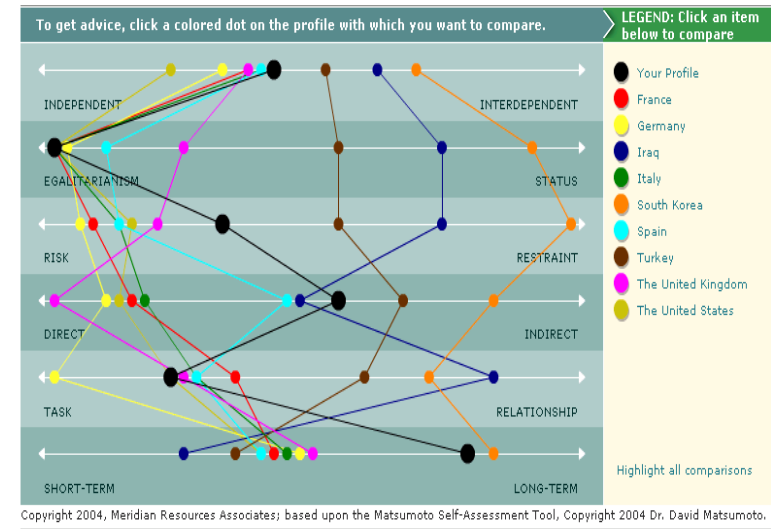


Tools to understand self, understand others  
... and improve collaboration



# Cultural Assessment (CA) Tool

- Culture is a set of assumptions, values, beliefs or traits shared by a specific community.
- Culture influences how people believe, think, and act.
- Cultural differences may have a negative affect on team performance.
- Approach to Cultural Assessment:
  - Apply tools from industry to the military environment.
  - Focus on inter-cultural rather than cross-cultural team performance.



**GlobeSmart® Commander**



# ***1<sup>st</sup> Three of Six Key Dimensions of Culture***



## **Independent**

- Take more individual initiative
- Use individual decision making styles (e.g., brainstorming)
- Reward / recognize individuals

## **Interdependent**

- Focus more on cooperation and group goal
- Use group decision making styles (e.g., consensus, meet before the meeting)
- Reward / recognize group

## **Egalitarianism**

- Self-directed
- Flexibility in roles
- OK to challenge opinion of people in power

## **Status**

- Enforce / follow guidelines
- Appropriate behavior for different roles
- Status and position respected

## **Risk**

- Demonstrate quick results
- Flexibility and initiative valued
- Speed valued more than thoroughness

## **Restraint**

- Spend time on background research
- Establish proper processes and systems
- Take time before making a change

# ***2<sup>nd</sup> Three of Six Key Dimensions of Culture***



## **Direct**

- Explicit and to the point
- Openly confront difficulties
- Constructive feedback

## **Indirect**

- Carefully consider how things are said
- Avoid discussing difficulties in open forums
- Personal dignity / face issues are important

## **Task**

- Move quickly to business, relationships develop alongside
- Relationships develop quickly
- Focus on what you do, achievements

## **Relationship**

- Relationship-building is a critical part of getting the job done right
- Relationships develop slowly over time
- Focus on who you are, network

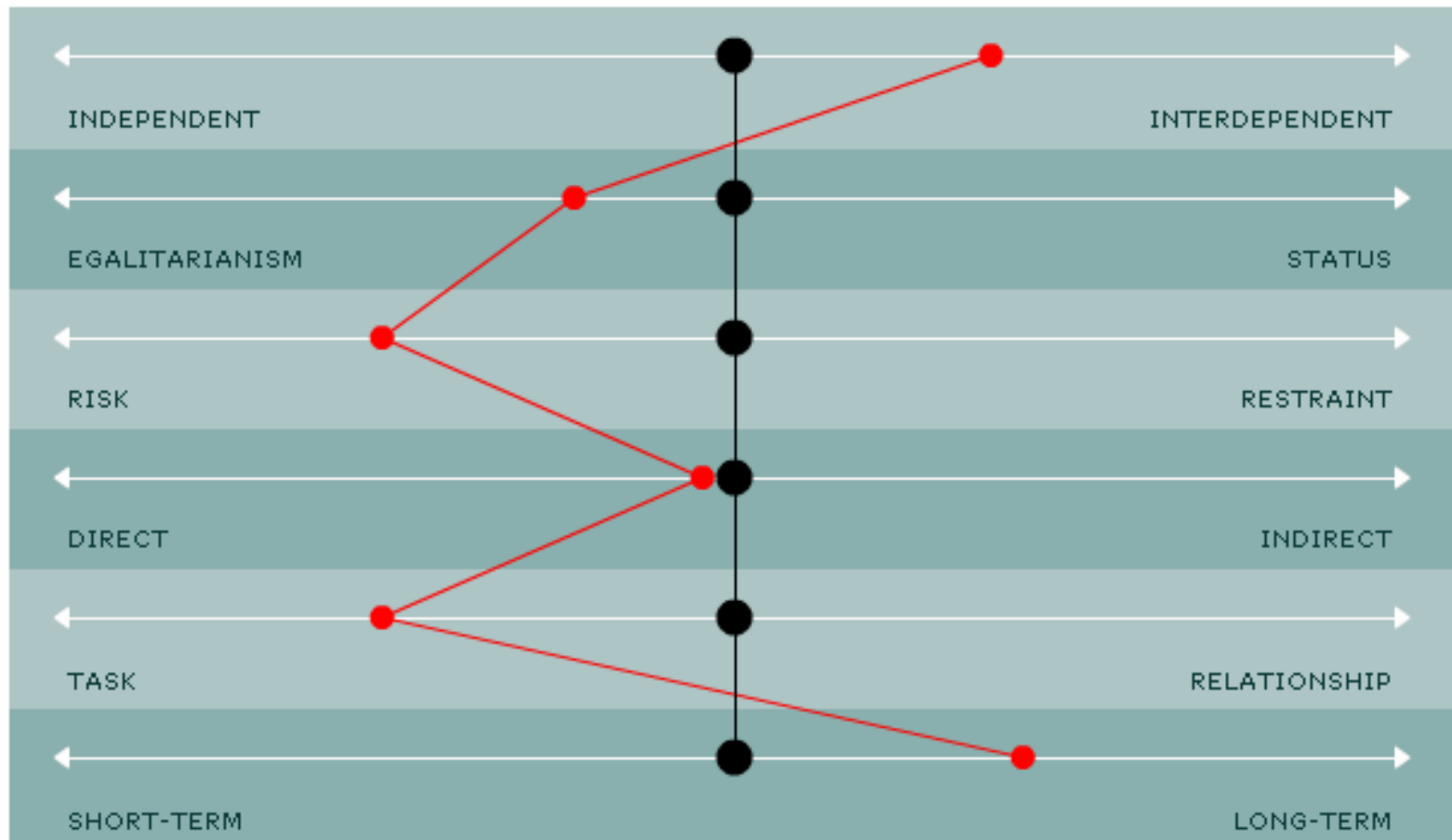
## **Short-term**

- Demonstrate immediate results
- Efficiency and speed important to decision making process

## **Long-term**

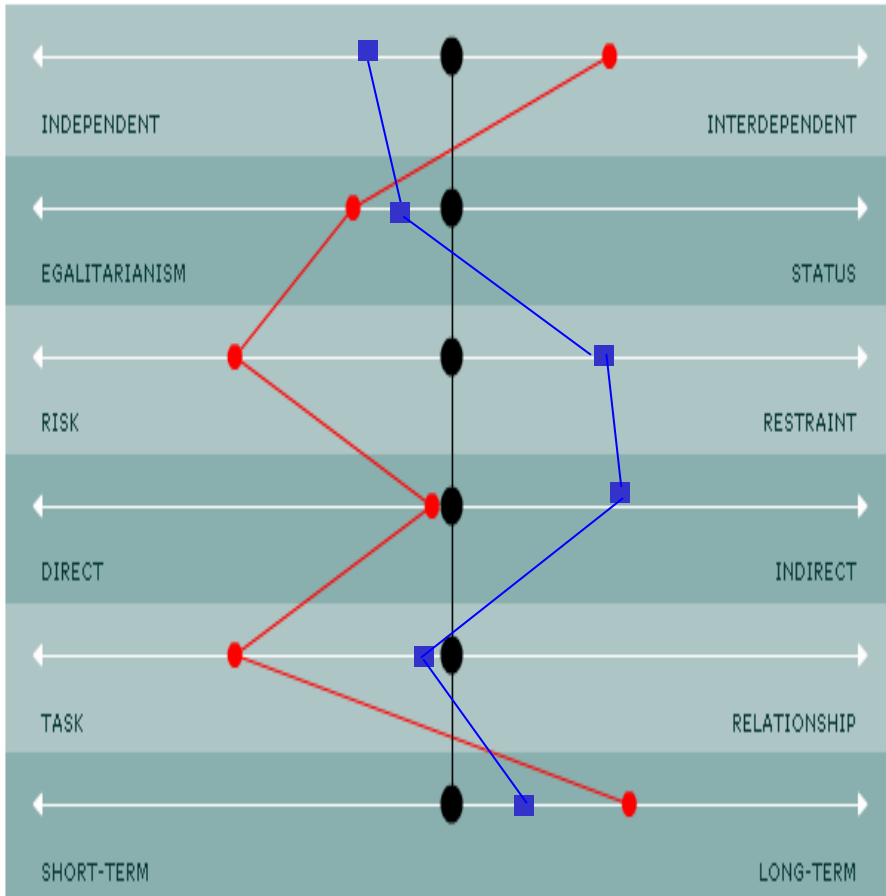
- Emphasize big picture and long-term results
- Thoroughness, consensus-building, and discussion of possible outcomes important

# ***Sample personal profile generated by Globesmart®***



Copyright 2004, Meridian Resources Associates; based on the Matsumoto Self-Assessment Tool, Copyright 2004, Dr. David Matsumoto.

# ***Globesmart® Commander Cultural Gap Analysis***



## **Behavioral Influences**

**Individuals can have significantly different culturally based cognitive biases that influence their behavior.**

**In concert with cognitive biases of others, resulting behaviors will either enhance or damage team performance.**

**Leaders and teams who recognize those biases and understand the impact of culture on teamwork are better prepared to adapt, as needed, to ensure mission success.**

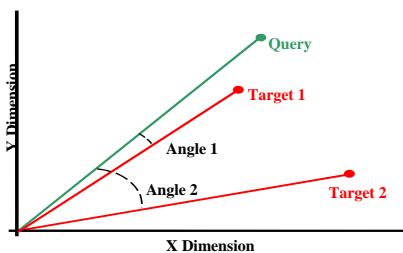
# Latent Semantic Analysis

## What is it?

- LSA is a computational approach to modeling language and knowledge.
- Automated technique for text understanding that learns by “reading” large bodies of representative text.
- Can make judgments of similarity on any new text using pre-trained semantic space

## How does it work?

- Compares the holistic meaning vectors of any two texts (news stories, chat contributions, training documents, ...)
  - Compares and determines degree of semantic relatedness between any two texts
- Initially represents terms and documents in a matrix as a weighted count of occurrences (global entropy, local log weighting on terms).
  - Result is a very large, very sparse matrix (~100-200K terms X ~100K-1M + documents)
- Uses Singular Value Decomposition to decompose the matrix and reduce dimensionality
  - Result is a high dimensional semantic space
  - Each term and document represented as vectors--sets of 300 numbers
  - Vectors represent overall gist or meaning of words and passages



## LSA Metrics

- Shared Meaning
- Expertise
- Document Retrieval
- Comment Quality
- Team Performance



**The Commander could use LSA to inform and moderate team discussions to ensure the expertise of the team members is reflected in the optimal solution!**

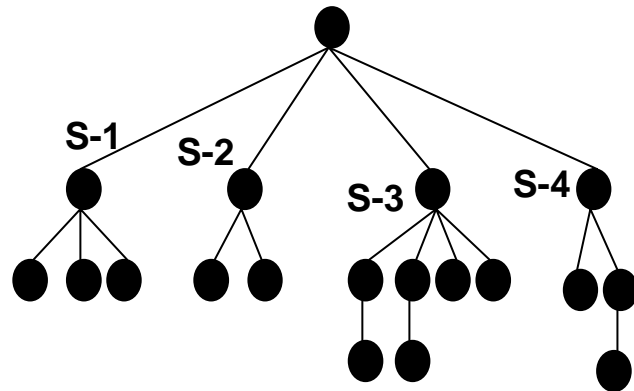
# ***Machine Learning-based Team Communication Analysis***

- Judge quality of team performance from communication stream and prior team performance measures
  - Typed
  - Spoken
- Current research results
  - Accurately predicts overall team performance from discourse
  - Categorizes statements made by team members
    - *Uncertainty, planning, acknowledgements, ...*
  - Robust performance when combined with Automatic Speech Recognition Systems
  - Language independent (English, Arabic, Swahili, Hindi, ...)
- Output
  - Metrics to track team behavior and performance
  - Feedback for Commanders
  - Automated AARs

# Dynamic Network Analysis



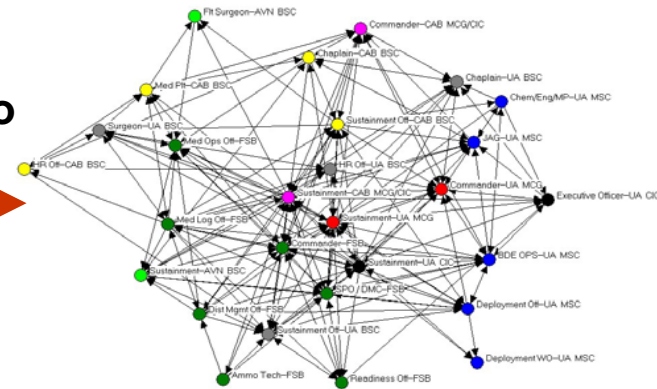
**DNA is a computational approach to modeling and simulating interactions among people, knowledge, resources, and tasks**



**Traditional Brigade Staff Hierarchy: UA Formal Structure**

**EBO moves from traditional to nodal networks.**

**Making sense of EBO informal nodal networks requires a special type of network analysis tool suite!**



**UA Nodal Operations: Informal Network**

## DNA Metrics

- Who knows whom – Centrality, Between-ness, Cliques
- Who knows what – Expertise, Exclusivity
- Who does what, when – Workload, Precedence
- How much is done – Workload, Cognitive Demand, Complexity

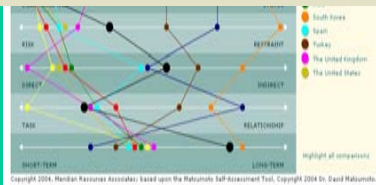
	People / Agents	Knowledge / Resources	Events / Tasks
People / Agents	Social Network	Knowledge Network	Attendance Network
Knowledge / Resources		Information Network / Substitutes	Needs Network
Events / Tasks			Precedence Ordering

# Forming, Supporting, and Measuring Team Performance

## Formation (Yellow Pages)



- Who and what expertise do we need
- Who is available
- Who works well together



Your contributions to the discussion group rate a score of **Good** overall. To improve your score, you might think about the following components and whether or not you've addressed them sufficiently in the contributions you've made to the discussion: **Enemy**, **Alternate Route**.

Your Contributions			
Subject	Find Related	Author	Date
Where's PAQ?	Notes	References	leaderR2 06/03/02 09:12 AM
Mission_Energy	Notes	References	leaderR2 06/03/02 09:28 AM
Final Thought	Notes	References	leaderR2 06/03/02 09:31 AM
Mission_Energy	Notes	References	leaderR2 06/03/02 09:25 AM

Jump to: [Trouble in McLoth](#) [Jump](#)

## Coach

- Support team member interactions
- Identify gaps in knowledge and expertise
- Establish metrics for success

Oil and conflict in Sudan, Page 1	(61)	Notes	Notes
Who is drilling in Sudan?, Page 1	(58)	Notes	Notes
Oil and conflict in Sudan,		Notes	Notes
Oil and conflict in Sudan,		Notes	Notes
Oil and conflict in Sudan,		Notes	Notes
Oil and conflict in Sudan, Page 15	(54)	Notes	Notes

## Meter

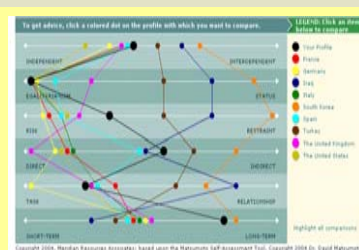
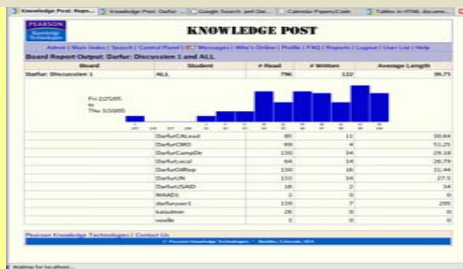
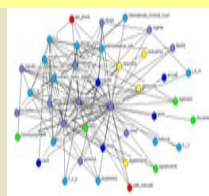
- On task to completion
- Monitor sources for new information



Number of organizations	47
Number of resources	40
Number of agents	126
Number of tasks	42
Number of locations	48
Number of knowledge	62

## Understanding

- Display team processes
- Display team networks (social, knowledge, resources)
- Display team performance





# Example of TAC in Action

## The Darfur Simulation

**Executed a 10 Day Simulation based on Actual Darfur Mission**

**Darfur is a classic example of an EBO mission**

- Ongoing conflict in the Darfur region of western Sudan
- Government-supported Arab militia vs. non-Arab peoples of the region
- Estimated 300,000 deaths
- 20+ ethnic groups affected, with more than 1.8 million people displaced
- 50+ NGOs operating



### The Mission

On order, COL Fernandez deploys to South Darfur state to assume command of all US forces comprising Multinational Force Darfur Watch. When directed, US forces support MNF operations to restore order and stability to the region.



Internally displaced persons (IDPs) are being forcefully relocated and denied access to humanitarian aid.



Rebels are using boys as young as 12 to carry out attack orders.



Rebel forces are attacking foreign oil industry workers and infrastructure.

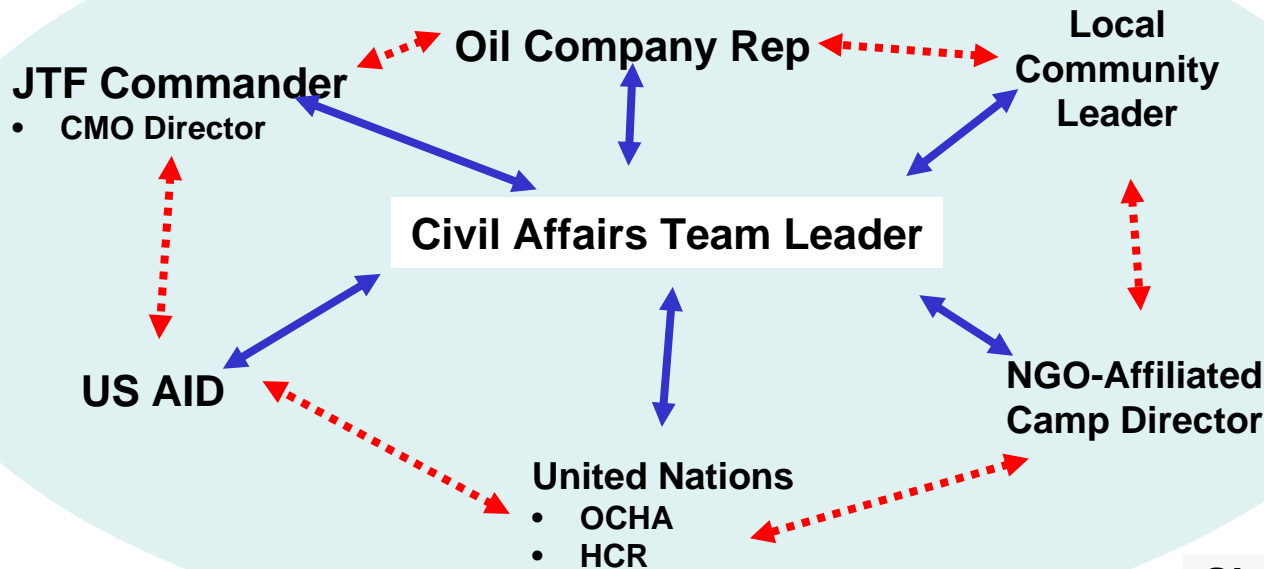
# The Darfur Mission

## A “Wicked” Scenario

A problem is an **evolving** set of interlocking issues and constraints.

The problem solving process is fundamentally **social**.

**Stakeholders** vary in goals, culture, and frames of reference



The constraints on the solution **change** over time.

Since there is no definitive problem, there is **no definitive solution**.

Complex problems are a **social negotiation**

“On **any given day**, I deal with the **political realm** of the Coalition Provisional Authority, the **humanitarian realm** of the NGOs, and the **military realm** of firefights, improvised explosive devices, snipers, [and/or] mortar attacks.” Commander in Iraq: Bde Cdr, 1st AD after 16 days in command

# Team Adaptability

## Identifying and Correcting a Problem

### Team Coach

Identify gaps in knowledge and expertise

Determines from the dialog that there is a need for a SME to review the child soldier rehabilitation plan

Civil Affairs: We need to assist the MNF, local authorities, and NGOs in the safe recovery of child rebel soldiers seeking freedom  
USAID: There was a successful project in Burundi.  
UN: Who knows about the program?

#### DNA BIOGRAPHY

Name: Anchita Ghosh

Field: Humanitarian Aid

Current Position: East Africa Regional Director for Save the Children

Areas of Expertise:

Child protection specialist:

Urban street children

Orphaned refugees

Rehabilitating child soldiers

Program manager:

Multi-partner development

Large field programs

Analyze texts from Burundi child soldier rehabilitation projects to identify possible candidates

#### Child Soldier Reintegration Project

- First began in November 2003
- 125 children and adolescents have been reintegrated into the community of Karusi
- UNICEF-funded project began in November 2003, expected to last 11 months

Education:

BS Psychology, University of Delhi

MSW University of Manchester, UK

Cultural Background: Ugandan citizen.

Family of Hindu Punjabi origin.

Languages: English, Punjabi, Hindi, Swahili.



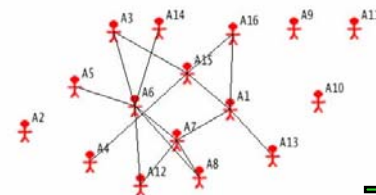
**Select**

### Team Formation

Determine what expertise is needed

### Understanding

Show social and knowledge networks

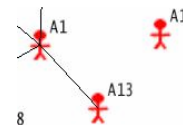


### Team Formation

Determine who is available and will work well together

Cultural Assessment ranks and filters the possible candidates

The candidates are filtered based on availability



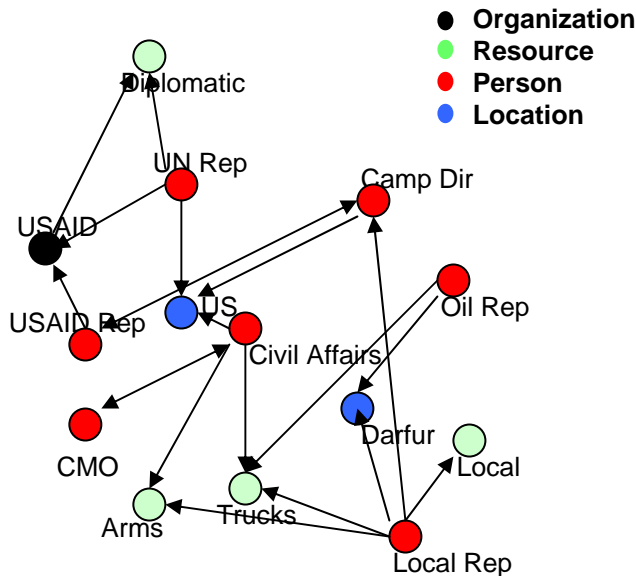
### Team Meter

Team is back on track

# Team Self Correction

## Understanding

Display team networks (social, knowledge, resources, etc.)  
Display team performance



## Different Roles – Different Agendas

Role	Agenda	Cultural Framework	Participation Rate
Civil Affairs	Coordinate with the JTF commander's office to provide local threat intelligence and protection	Military officer: embedded in hierarchal organization but has close ties to host nation's bureaucratic civil community.	14%
Refugee Camp Director	Procure safe transport for food and people Encourage local population to register at camp for services	NGO humanitarian aid worker: Decentralized organizational structure but has ties of varying degrees to most stakeholders, including IDP population, UN, and military.	29%
CMO	Survey status and needs of refugee camp	Military officer: embedded in hierarchical organization but has close ties to diplomatic community.	3%
UN	Coordinate high level goals and meetings	International humanitarian official: embedded in international humanitarian organization but has close ties to NGO workers and diplomatic community.	27%

## Implications

- Isolated military personnel are on the periphery of the problem solving process.
- Need to encourage higher rates of participation between military and non-military team members.

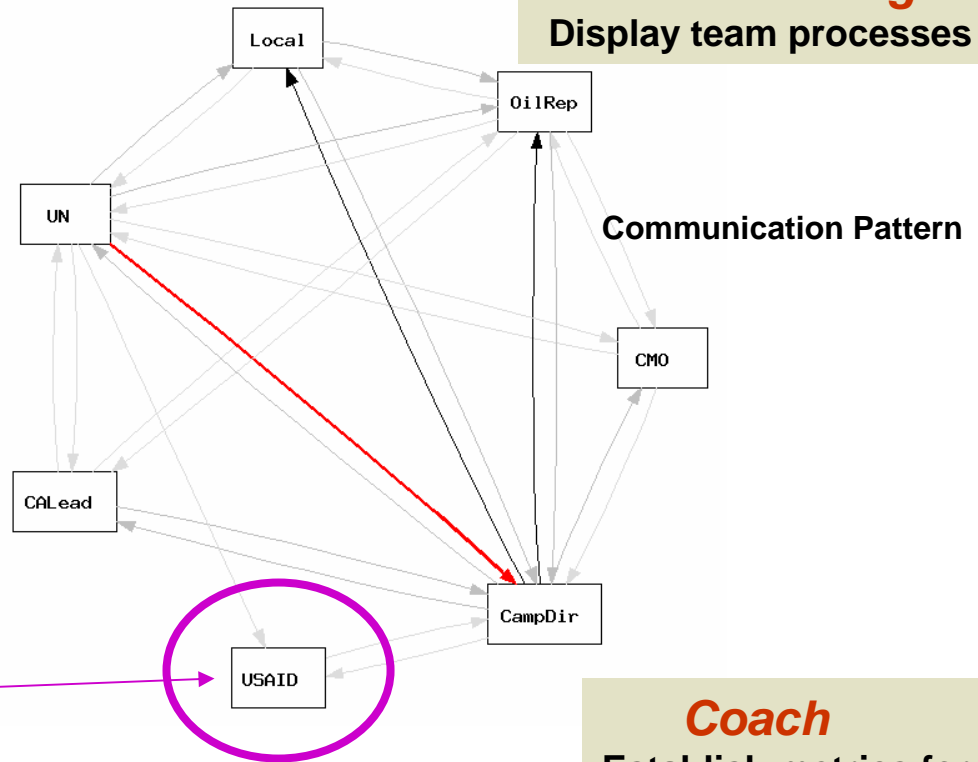
# Team Self Awareness

## Understanding

Display team performance

Consensus Over Entire Discussion

Role	Consensus Score
UN	.768
Camp Director	.759
CA Lead	.720
Oil Rep	.718
Local	.701
CMO	.576
USAID	.524



Understanding  
Display team processes

## Coach

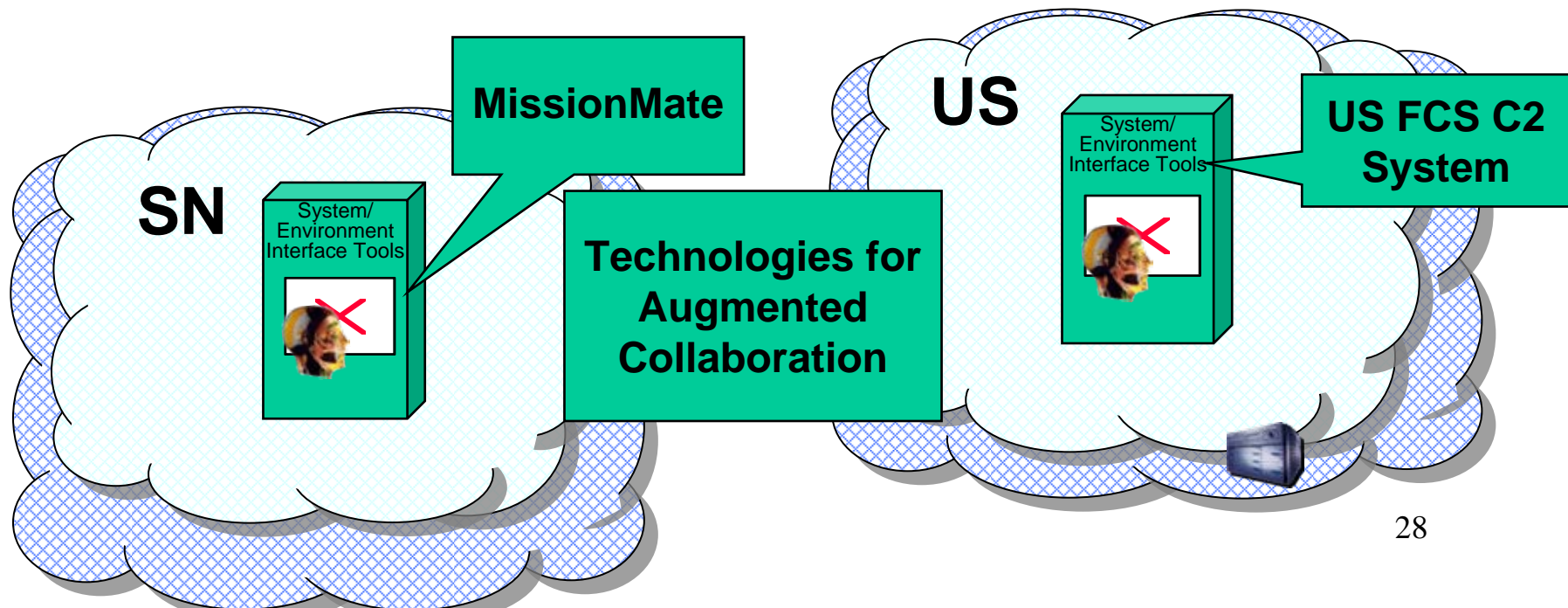
Establish metrics for success

Comparing expected and actual levels of performance

- USAID rep's low participation and consensus scores target him for intervention.
- However, his position as a high ranking government official means he is expected to have little involvement in the day-to-day issues.
- Expected performance matches actual performance

# US and SN Experiments

- **Participants** – US and SN Command Staff
- **Scenario**
  - Bio-terrorism
  - Humanitarian Relief
- **Independent Variables**
  - Command System
  - Augmented Collaboration Tools
- **Dependent Variables**
  - Team Processes
    - Shared Mental Model
    - Team Situation Awareness
    - Trust
  - Outcome Measures





# ***Summary of Cultural Adaptability Research***

- **ARL HRED Cultural Adaptability Research Program has been formalized in 2 international working groups:**

- **Cultural Diversity in Cognition and Teamwork, HQ Supreme Allied Command - Transformation, Futures and Engagement, Concept Development and Experimentation**
- **Adaptability in Coalition Teamwork (ACT) RTO HFM TG 138**

- **FY06 Research Venues:**

- **US and Singapore Exercises**
- **Allied Warrior 05**
- **Multinational Experiment 4**

- **SABRE (Situation Authorable Behavior Research Environment)**



**QUESTIONS?**